HYDROLOGY

Characterization

The hydrologic characteristics of the North Fork Coquille Watershed are controlled by precipitation in the form of rain and are typical of the Coast Range. The peak flows, low flows, annual flows and groundwater levels are all dependent on the amount, intensity and distribution of rainfall. The close correlation between precipitation and runoff indicates that this system rapidly translates rainfall into runoff (flashy). This is due to a high drainage density, low bedrock permeability, coarse textured and shallow soils, high precipitation, and steep slopes. The Watershed occasionally has snow but the quantity or duration of the snow on the ground does not produce serious rain on snow events. The climate is characterized by dry summers, and mild, wet winters with most all the precipitation in the form of rain[1].

From 1960 to 1980, the average annual precipitation in the Watershed ranges from about 80 inches near the northeast boundary of the Watershed to less than 60 inches around the mouth of the North Fork Coquille River (Froehlich *et al.* 1982). During the same period, the average dry season rainfall (May through September) is 9 to 10 inches for the headwater areas on the east end of the Watershed and tapering to 7 inches at the mouth of the North Fork Coquille (McNabb *et al.* 1982). The BLM precipitation gage in lower Cherry Creek, near McKinley, Oregon at an elevation of 600 feet recorded an average annual rainfall of 57 inches for the 1985-1993 period. Average dry season precipitation (May -September) at this site for the same period was 0.28 inches (Coos County Water Resource Records). These measurements reflect a series of drought years since 1984. About 80% of the precipitation falls from October to March, with half occurring between November and January. Winter rainfall can be steady for several days and intense rain periods can produce 4 to 6 inches of rain in 24-hours (Townsend *et al.* 1977). Distribution of annual stream flow is closely related to the distribution of annual precipitation. Thus, high flows occur during the winter months and low flows predominant in the summer. Most of the precipitation results in stream flow, with as little as 1 to 2 inches going to groundwater recharge, because the thin, coarse textured soils provide little ground water storage. The lack of ground water storage results in systems that are very responsive to precipitation events.

<u>Stream and Weather Monitoring Stations</u>: The nearest active U.S. Geologic Survey gaging station (#14325000) with a long period of record (1916-1926, 1928-present) is on the South Fork Coquille River at Powers. Discontinued stations on or near the North Fork Coquille Watershed include the Middle Fork Coquille near Myrtle Point (#14326500), North Fork Coquille near Fairview (#14326800) and the North Fork Coquille near Myrtle Point (#14327000).

The Bureau of Land Management currently operates gaging stations within the North Fork Coquille watershed on Cherry Creek (#14326850) and Middle Creek near McKinley (#14326860). However, these gages provide only a short period of record, having only operated since 1983. In 1997 the National Weather Service installed three new gaging stations in the Coquille Subbasin. They are on the North Fork Coquille near Cooper Bridge (#14327005), on the South Fork Coquille at Myrtle Point (#14326510) and on the Coquille River near Rink Creek (#14327055).

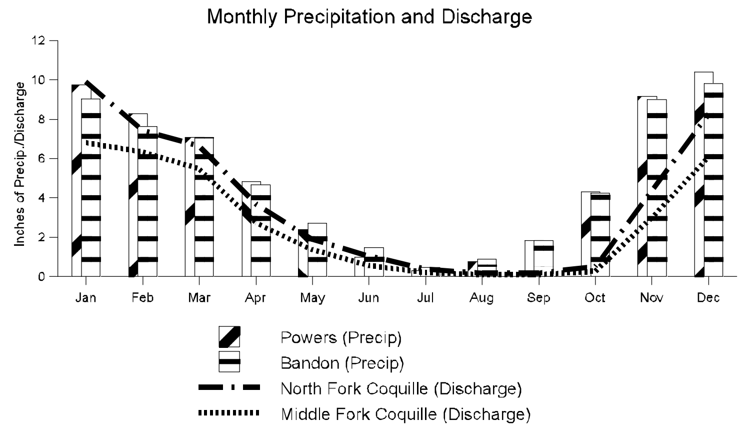
Precipitation was recorded at McKinley from 1897 to 1944. The BLM maintained a rain gage inside a progeny plantation in the Cherry Creek Drainage, until the trees in those plantations grew too tall to allow for continued rain data collection. Precipitation records have also been maintained from 1932 to present, and 1910 to present at Powers and Bandon respectively. An operating RAWS station is on the

[1] Weather extremes do occur. The Coquille river froze over in 1888. The ice was thick enough to halt river boat traffic (Wooldridge 1971 pg 206). Myrtle Point and surrounding area had 6 inches of snow on the ground in March 1895 (Wooldridge 1971 pg 325).

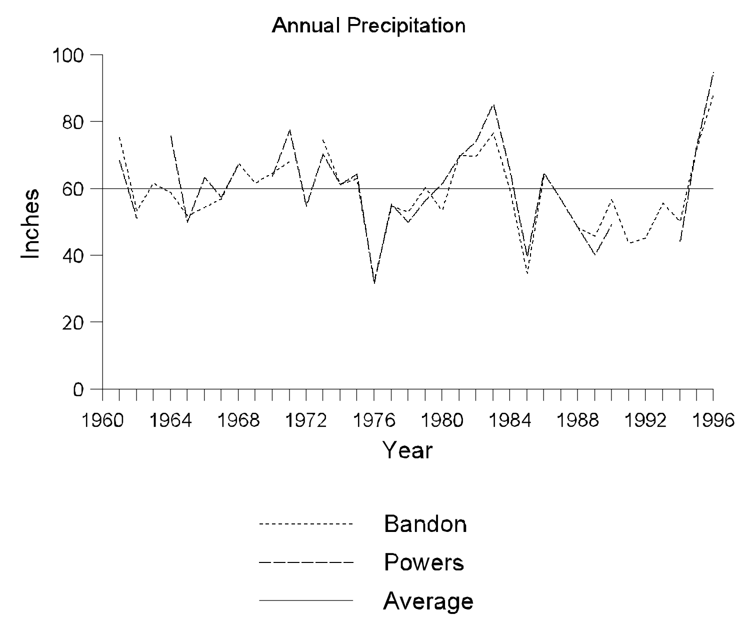
ridge where South Fork Coos, North Fork Coquille and East Fork Coquille Watersheds all meet. The nearest long-term precipitation record (1902 - present) is at the North Bend airport.

Current Conditions

Annual Flow and Yield: The average annual yield at the North Fork Coquille near Myrtle Point is 720,000 acre-feet (ODEQ 1991). Data from USGS stream gage on the North Fork Coquille near Fairview (#14326800), period of record 1963-1981, was used in to prepare the graph in Hyd Figure 1. The average annual yield of the Middle Fork Coquille River, USGS gage (#14326500), and precipitation data from sites in the Coquille Subbasin are shown for comparison. Hyd Figure 2 shows the year to year variation of precipitation at the Powers and Bandon stations, while Hyd Figure 3 shows the yearly variation in stream discharge at the Fairview stream gage.



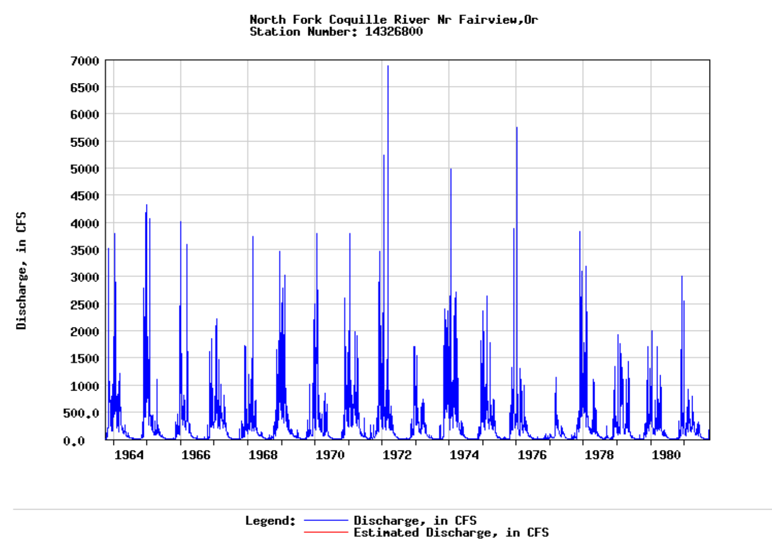
Hyd Figure 1



Hyd Figure 2

Flow Distribution: Hyd Figure 1 shows that approximately 60% of the annual runoff occurs between December through February, with January being the highest month. June through October contribute only 4% of the annual runoff and results in very low stream flows. This annual runoff distribution very closely follows the precipitation pattern and illustrates that the precipitation pattern and the distribution of annual runoff is directly related. Thus, the peak flows are observed during the winter months and low flows in the summer. The similar slope and shape of the lines show the strong correlation between discharge and precipitation. This correlation is indicative of "flashy" systems that have extreme fluctuations in stream flow; storm hydrographs that have short lag times with steep rising and falling limbs, and low ground water storage or recharge capacities. The limited ground water influence is important especially during the summer season when both precipitation and discharge drop to seasonally low levels.

Large to extreme flows occur less than 5% of the time, moderate flows occur 45% of the time, and low flows occur 50% of the time (Hyd Figure 3). Channel formation processes are caused by flows that fill the channel to bankfull or beyond, while channel dimensions are maintained by the frequent flows (flows less than bankfull).



Hyd Figure 3

Minimum Flow: Because rain is infrequent in the summer, stream flows become extremely low in mid August-October along the North Fork Coquille and tributary streams. Information from the USGS stream flow gage 14325000, near Powers OR. indicates that the lowest 7-consecutive-day low flows occurred between September-October in 1931, 1933, 1939, 1974, 1987, 1991, 1992 and 1994. The North Fork Coquille likely exhibited very low flows during those years. The return periods for these 7-day low flows are 20 years or greater. The low flows in 1933, 1991, 1992 and 1994 were 100 year events (Wellman *et al.* 1993). During these periods, there was essentially no live flow.

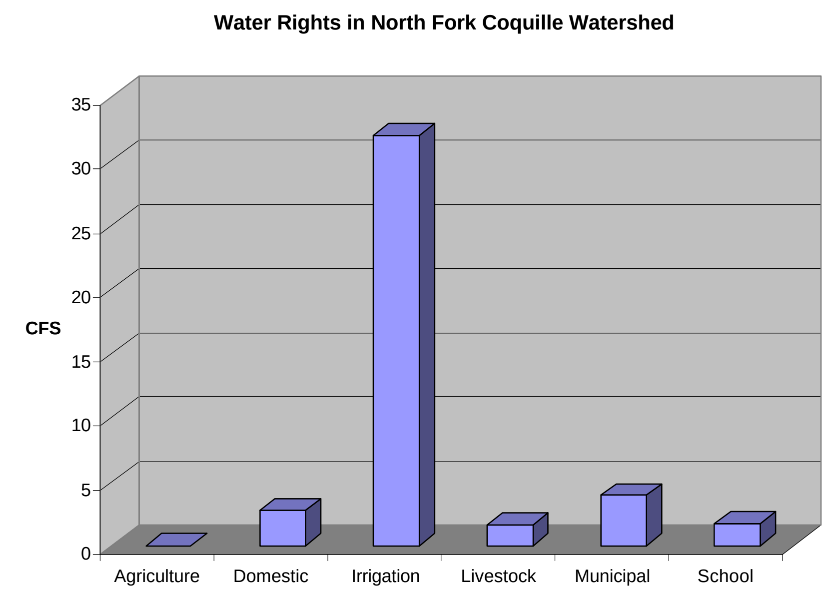
Many headwater first order streams are formed on coarse textured high permeability soils and dry up as the summer progresses. Streams that originate from seeps and drain fine textured, deep, high porosity soils types have a very low, constant flow, but may have dry spots in the channel in later summer. Higher order channels may have pools in late summer, but little live flow. During the summer/fall period, live stream flows are so low they are measured in gallons per minute. Stream flows increase slightly at night, because evapotranspiration demand is at its lowest point.

Peak Flows: A peak flow is the instantaneous maximum discharge generated by an individual storm. The sizes of the peak flows are highly variable form storm to storm and year to year because of the randomness of precipitation events. A frequency analysis is usually done to establish the relationship between the size of the event and its return period.

Flooding is a common occurrence in the Coquille Subbasin, which contains the North Fork Coquille Watershed, and can be severe and widespread downstream from Myrtle Point. The flood plain of the Coquille River extends from Bandon to Broadbent on the South Fork, up to Middle Creek on the North Fork and Elk Creek on the East Fork. Nearly all of the flood plain is agricultural land. High tides and intense storms contribute to flooding. Since the seasonal rainfall pattern is consistent through time, the major factor controlling runoff/flooding is the amount and timing of annual rainfall. The early 1980's were wetter than average and the mid-1980's to 1994 were below average. Starting in 1995, this pattern has begun to change with above average precipitation falling throughout 1996 and into 1997. The most recent flooding occurred in November of 1996, when an extremely intense storm system dropped 8.87 inches at Bandon and 8.28 inches at Powers between November 18-20.

Water Rights: There are approximately 340 water rights in the North Fork Coquille Watershed (OWRD 2001). A total of about 42 cubic feet per second (cfs) of stream flow is appropriated to water users for domestic use, irrigation, livestock and private municipal water supplies. The majority, about 76% is used for irrigation. Although many users are not metered, and therefore the exact value is unknown, this is a substantial diversion when measured against low summer flows in the North Fork Coquille system. Historical records from a discontinued USGS gaging station (#14327000) near the mouth of the North

Fork Coquille River show that mean summer flows for August and September were 44 and 49 cfs respectively for 23 years of record (1930-46, 1964-68). The minimum flow observed during this period was 1.2 cfs in August of 1968. (USGS 1990, p 353). This level would include an unknown amount of flow from the East Fork Coquille Watershed whose confluence is upstream of the gage.



Hyd Figure 4

Water in the North Fork Coquille system is over-appropriated (Van Gordon 2001) and, according to state law, no new water rights are being allocated except "where public interest in those uses is high and uses are conditioned to protect instream values" (OAR 690-410-070).

<u>Instream Rights:</u> Instream water rights are established by the State of Oregon to maintain flows that will support beneficial uses. Minimum instream flows were designated in 1992 for reaches of the North Fork Coquille and some of its' major tributaries. The table below lists minimum flows (instream water rights) for the reach near the mouth of the North Fork Coquille (OWRD 2001).

Table Hyd-1: Monthly minimum instream flows in cfs for the mouth of North Fork Coquille River

November - May	June	July	August	September	October
270	160	108	43.1	43.7	69.2

According to USGS data for 23 years of record (USGS 1990, p 353), the minimum instream flows for August and September listed above were met less than half of the time (50% exceedence is 39 and 32 cfs respectively). When flows fall below the above levels, consumptive water users with junior water rights may be restricted. However, according to the Coos County Watermaster, monitoring and enforcement of minimum instream flows in the North Fork Coquille is highly variable and subject to the availability of human and financial resources in the Coos County office of the Oregon Water Resources Department (Van Gordon 2001).

Reference Condition

The earliest documented major flood in the Coquille Subbasin was in 1861 and was the result of an intense rain on snow event of 12 hour duration (Wooldridge 1971). The 1861 flood in the Coquille Subbasin was just a part of a regional event, which among other things, produced the largest flood event recorded for the Willamette River. Summarized accounts in newspapers and letters of the time show this was part of a series of regional scale events that began with heavy snowfall in early November 1861. In western Oregon, this was followed by very heavy rainfall throughout December. Heavy precipitation continued until March 1, 1892. Between 75% and 80% of all livestock in the Northwest either froze to death, or starved, or was lost in the December floods. Many farm houses, most bridges, and whole communities were washed away (Meteorology Committee PNW River Basins Commission 1969).

Very heavy rainfall from January 28 to February 3, 1890 affected all of western Oregon. The 7-day totals for the Oregon Coast ranged from 15 to 20 inches of rainfall (Meteorology Committee PNW River Basins Commission 1969). In the Coquille Subbasin, the 1890 storm resulted in slides that transported boulder weighing up to 3 tons. Slides and associated debris lead to a 25-foot high dam break flood on the South Fork (Wooldridge 1971). Mahaffy (1965), in her chronicle of early settlers on Coos River also documented major flooding in 1890.

Other major floods in the Coquille Subbasin likely correspond to the November 23, 1909, December 28, 1945, November 23, 1954, and January 19, 1955 events reported by Mahaffy (1965) on Coos River. Two storms in rapid succession hit Oregon during November 18 to 24, 1909. During the period, 7-day totals ranged from 10 to 20 inches of rain along the coast with 4 to 6 inch totals for western inland valleys. Twenty-four-hour totals of 3 to 5 inches for December 27/28, 1945 were typical in western Oregon. The November 22 to 24, 1953 (a typo, or possibly reported as 1954 in error by Mahaffy?) affected all of western Oregon. The most intense part of the storm hitting the south coast with 1-day total of 4 to 8 inches and storm totals of 15 to 20 inches recorded (Meteorology Committee PNW River Basins Commission 1969). Other regionally noteworthy storms, not reported by Mahaffy, occurred in November 1896, October 1950, January 1953, and December 1964 (Meteorology Committee PNW River Basins Commission 1969). Large storms like these do exhibit variation across the affected area. For example, the 1964 storm caused a 50 to 100-year flood event in many watersheds including the South Fork Coquille where it is the flood of record. However, the 1964 flood was not a high magnitude event at Millicoma gage station in the Coos Subbasin. Interviews with residents in Middle Creek indicate there were extremely high flows occurred in 1950, 1953, 1955 and 1962.

The following dates or major storms are from the Coos Bay District files that document damage to the road system caused by major storms:

<u>January 1971</u> - There were high temperatures and heavy rains causing flood warnings. Slides and road damage were recorded in BLM timber sale related correspondence.

<u>January 1972</u> - Storm caused Park Creek to have a major failure and which also affected Middle Creek. Slide started on the Middle Creek-Burnt Mountain Tie road and ended at the Park Creek bridge near Middle Creek.

<u>January 1974</u> - Storm caused draws to flush out resulting in accumulation of debris in Cherry Creek that endangered a portion of the Cherry Creek Road and a concrete bridge on Cherry Creek.

<u>January 1976</u> - Storm event caused flooding, road failures (slumps and slipouts), slides, debris torrents, log jams, and culvert failures.

<u>December 5, 1981</u> - Storm event caused flooding, road failures (slumps and slipouts), slides, debris torrents, log jams, and culvert failures. During this storm, the North Bend Airport recorded 5.60 inches of rain in 24-hours.

Major storms hit in mid-December 1995, February 6-9, 1996, November 18-19, 1996, December 10-12, 1996. The Register Guard Newspaper (March, 1, 1996) reported the December 1995 storm as a 1 in 5 year windstorm, a 1 in 10 precipitation event and a 1in 25 year flood event. The 24- hour rainfall on November 18, 1996 dropped 6.67 inches at the North Bend Airport and 9.35 inches at the Burnt Mountain RAWs station. The World Newspaper reported the December storm to be the biggest since

1962 (December 12, 1996). The rapid succession of storms in 1996 was thought by some to be a symptom of global warming. However a climatologist interviewed by the Eugene Register-Guard Newspaper (March 1, 1996) argued that our long-term weather in Oregon shows a pattern of 20-years cool and wet followed by 20-years of mild and dry. The climatologist, in the 1996 interview, observed Oregon had experienced two droughts and generally warm and mild conditions since the mid-1970s. The 20-year period that preceded was wet and cool while the 1930s was dry and mild.

Syntheses and Interpretation
The available stream flow data is insufficient to draw any conclusions on the similarities or differences between historic and current conditions in the North Fork Coquille Watershed. Even if we had a complete record of flow at a single gage site dating back to before widespread logging and conversion of the bottom lands to agriculture, we could draw few conclusions. Precipitation variations across large areas, and through time, often having a greater influence on the stream flow amounts that do management activities. Therefore, research efforts to measuring the influence of different management activities on stream flow are typically done by conducting studies of small paired treated/untreated watersheds that are calibrated using several years of pretreatment flow data. The design of these studies uses small area watersheds in close proximity to reduce affect of variation in precipitation patterns across a landscape on stream flows. These experiment designs also use paired treated/untreated watersheds to eliminate the variation in precipitation patterns through time on stream flows. While paired watershed studies do show statistical differences between some levels of management and the no treatment control in small drainages, this approach has limitations for quantifying the influence of management on whole watersheds the size of the North Fork Coquille because the variation of precipitation across such large areas can be greater that the change in flows attributable to management. This can make stream flow changes due to management statistically indistinguishable from the natural variability precipitation patterns across large watersheds. Consequently, the reader is reminded that the experimental results cited in this chapter are often based on observations in small drainages. These studies show that under some circumstances, management actions can have a statistically significant influence on water yields at the small drainage scale. Those observations should only be extrapolated to the subwatershed or watershed scale with the understanding that in large hydrologic units, management caused changes in stream flow may be estimated, but in practice are often indistinguishable from natural range of variability and therefore difficult to quantify in a way that is statistically significant at the larger hydrologic unit scale (Huff *et al.* 2000; Duncan 1986 cited in Adams & Ringer 1994). The reader is further reminded that studies on stream flows typically compare partially cut to completely denuded drainages to control drainages that are fully forested and unaffected by recent disturbances. This does not directly equate to determining the differences between a managed forest and an unmanaged forest under natural conditions when wildfires had a larger roll in influencing landscape patterns.

<u>Annual Yield</u>: Forested areas use large amounts of water to satisfy evapotranspiration demands. In western Oregon, evapotranspiration can exceed 25-inches annually. However, site conditions determine how much evapotranspiration will actually occur, and depends on slope, aspect, soils, type of vegetation and climatic conditions. In addition, increases in water yield predicted to occur following clearcut harvest, due to reduced evapotranspiration, can be offset by the reduction of cloud water interception on coastal fog-affected stands (sources summarized by Jones 2000).

A 1979 study by Harr and others in western Oregon showed water yield increases averaging 43% (29 cm) during the first five years following clearcutting a small drainage. While the largest absolute increases in yields occurred in the winter, the largest relative increases in water yields occur in the fall and spring. While the yield increases from recently clearcut small headwall basins can be large, their influence on the yield of the larger parent watershed can be overshadowed by the normal water yields from uncut or reforested areas. Estimates of potential water yield increases from large forested watersheds are in the range of 3-6%, assuming the use of 70-100 year rotation intervals (Harr 1983). In practice, changes of 5% and less are indistinguishable from natural variation in water yields in large watersheds (Huff *et al.* 2000).

After examining some 90 watershed studies worldwide, Bosch and Hewlett (1982) determined that water yield increases are usually only detected when at least 20-30% of the watershed has been harvested. Adams and Ringer (1994) in their summary of literature on timber harvest and water quantity noted the stream flow increases observed following logging decrease with time and eventually disappear in about 20 to 30 years in western Oregon and 40 to 60 in eastern Oregon. These changes in water yields come about as the new stands regenerated following clearcutting begin to exhibit transpiration rates similar to that of the original stands and thus reach hydrological maturity.

Table Hyd-2 shows the percent of BLM lands that will support stands of trees less than 10, 20, 30 and 40 years old in 2000 and every 10^{th} year there after for four decades into the future. The assumptions used to populate the table are a 60-year rotation resulting in regeneration harvest on 1,500 acres per decade in the Matrix, no species protection buffer areas for survey and manage species or for threatened and endangered species, and the LSR and Riparian Reserves will be managed for late-successional habitat. In practice, fewer acres will be available for regeneration harvest because species protection buffers will reduce the area available for regeneration harvest, and commercial thinning will delay the culmination of mean annual increment, which will length rotations on a stand by stand basis. This would be balanced by some hardwood conversion and natural disturbances occurring on the reserve lands resulting in a small portion of those sites being converted into young stands. Assuming stands in the Watershed reach hydrological maturity at age 30 years (Adams & Ringer 1994), then in the year 2000, 75% of the stands on BLM lands in the Watershed were hydrologically mature. The percent of the BLM land in the Watershed that is hydrologically mature reaches a maximum of 88% about the year 2020, and remains at that level into the future. The amount of BLM lands that is hydrologically mature, inside the Riparian Reserve and Late-Successional Reserve, will approach 100% by 2030. This approach of using harvest levels as an estimator of cumulative effects does not take into account regional variability, harvest location, yarding system, or road location and density, and assumes a direct causal mechanism between timber harvest and the magnitude of impact. In most cases, it is not the fact that trees were harvested, but how they were harvested, where on the landscape, the methods of roading and yarding, the degree of riparian protection, and other factors that ultimately determine the impact of a forest practice operation (Reiter; Beschta 1995). Taking the available literature in consideration, changes in present and future flows associated with past and projected timber harvest on BLM land may be difficult to observe or if observed may be difficult statistically to validate. Given the protective measures provided by the Forest Plan, the restoration and maintenance of Riparian Reserve functions with respect to large wood and coarse sediment recruitment potential, and streambank stability will have much more observable affect on watershed recovery.

Table Hyd-2: Percent of BLM Land Supporting Stands That Are Less Than 10, 20, 30 and 40 Years Old in the Years 2000, 2010, 2020, 2030 and 2040

Stand Age Classes:	Acres by age class for the years:				
	2000	2010	2020	2030	2040
0-9	1,481	1,500	1,500	1,500	1,500
10-19	3,369	1,481	1,500	1,500	1,500
20-29	4,515	3,369	1,481	1,500	1,500
30-39	5,909	4,515	3,369	1,481	1,500
40-49	1,765	5,909	4,515	3,369	1,481
50-59	1,750	1,765	5,909	4,515	3,369
60+	18,059	18,309	18,574	22,983	25,998
totals	36,848	36,848	36,848	36,848	36,848
percent of BLM land supporting stands <10 yrs old	4%	4%	4%	4%	4%
percent of BLM land supporting stands <20 yrs old	13%	8%	8%	8%	8%
percent of BLM land supporting stands <30 yrs old	25%	17%	12%	12%	12%
percent of BLM land supporting stands <40 yrs old	41%	29%	21%	16%	16%

<u>Streamside Stand Retention and Thinning Affects on Water Yield</u>: Much of the research that is the foundation of our understanding of how timber harvest affects water yields was done in the 1950s, 60s, and 70s. These studies typically involved clearcuts and other land treatments that went from ridge top to stream edge. This was in keeping with conventional logging practices of the time, but does not reflect practices on Federal lands since the implementation of the Forest Plan in 1994. Little research has been done in the Pacific Northwest looking at the affects of partial cuts, thinnings, patch cuts, or the affects of clearcutting while retaining streamside buffers on water yields.

In a hydrologic study on three small watersheds near Newport Oregon, one 750-acre watershed was treated using three clearcuts averaging 62 acres each while leaving a stream buffer of 50-100 feet on each side of the stream along the main channel. No changes in peak flows were observed, even during fall and spring storms (Hall *et al.* 1987).

An average annual yield of 2.4 inches was detected for four years after a shelterwood cut removed 50% of the basal area of a southwest Oregon Cascades watershed. A patch cut watershed, which had 20 small clearcuts totaling 30% of the watershed resulted in an average water yield increase of 3.5 inches (Harr *et al.* 1979). Harr and coauthors (1979) noted that the hydrologic changes caused by timber harvest cannot be separated from roads or soil disturbance. Tractor logging resulted in compacted soils on 13% of the shelterwood cut watershed, and on 4.5% of the patch cut watershed (15% of the area inside the logging units). In addition, roads occupied 1.6% of the shelterwood unit and 1.7% of the patch cut watershed.

Huff and others (2000) modeled the changes in water yields in the Sierras resulting from a large-scale thinning and vegetation program aimed at improving fire resilience, providing biofuel, and sustainable generation of other forest products. They concluded the thinning and vegetation management program would, on average, increase water yields about 1%. U.S. Geological Survey considers stream-flow measurements within 5% of the actual value for 95% of the observations to be “excellent,” and considering the variability of annual flows, the expected changes attributable to the projects are unmeasurable. Where individual trees or small groups of trees are harvested, the remaining trees will generally use any increased soil moisture that becomes available following timber harvest. Because of such “edge effects,” partial cuts, like shelterwood cuts and thinnings, are expected to have little effect on annual water yields.

Trees within the Riparian Reserve intercept, and transpire the water in the soil made available by up slope harvest activities in the Matrix. For example, a single mature pine tree in the northern Sierra Nevada depleted soil moisture to a depth of about 6 meters and a distance of 12 meters out from the trunk. This one tree transpired about 88 cubic meters more water than a surrounding logged area. This summer transpiration loss is equivalent to about 180 mm of rain over the affected area (Ziemer 1968). Chen (1991), in his study of edge effects on microclimate patterns, found that edge effect, with respect to soil moisture, was not detectable at distances greater than 197 to 295 feet (distance depended on aspects) into the stand from the stand's edge against a recent clearcut. This suggests the hydrologic response of a landscape, where Riparian Reserves are employed, may be very different from the response of watersheds denuded from ridge top to creek as part of research projects.

<u>Minimum Flows</u>: Low flow volumes may initially increase following timber harvest, but the effect is short lived (5-10 years). In addition, the absolute difference in additional quantities of stream flow is small (Harr & Krygier 1972, Hall *et al.* 1987). However, increases in low volumes may be beneficial to fish during the summer when temperatures are high and flows are lowest. This is due to the fact that the water temperature change produced by a given amount of heat (direct solar radiation, long wave radiation, convection and stream bed conduction) is inversely proportional to the volume of water heated, or in other words, the discharge of the stream (Brown 1983). Stream side vegetation left in place by using buffer strips can intercept and transpire the additional water in the soil that was available by cutting the upslope stands. Timber harvest can result in a decrease in summer low flow volumes if conifers are replaced by red alders. This is caused by red alder's greater evapotranspiration rates compared with the conifers they replaced in a watershed (Hicks *et al.* 1991). The removal of beaver from stream systems has resulted in the reduction in the number of beaver dams. The loss of beaver dams and log jams reduced volume of water stored in pools along the stream channels. These structures released water slowly over the summer.

Summer flows are a result of subsurface flow being released during the late spring/summer and are primarily dependant upon soil types, soil depths and porosity. Many soil types in the South Fork Coos Watershed are shallow and coarse textured and do not retain much water. The bedrock geology in the Watershed does not favor ground water accumulation.

<u>Peak Flows</u>: Peak flows are predominantly generated by rainfall events in the Coast Range. In a literature review comparing studies of nine rain-dominated coastal streams, eight showed an increase in peak flows following harvest and one showed a decrease. In over half these studies, winter peak flows increased, and the smaller fall and spring peak flows increased in 8 of the 9 studies. The change ranged from a -36% to a +200% (Reiter & Beschta 1995). These studies considered only small drainages (30-1,000 acres), and did not consider timing and synchronization or desynchronization effects as water routes through larger mainstem streams. These studies did not consider the distribution of harvest units throughout the watershed. In three of these studies, the peak flow increases were not statistically significant.

<u>Extreme Flows</u>: Past and present extreme floods (greater than a 20-year return frequency) are the result of natural weather patterns and flashy watershed response. Extreme floods in the lower reaches of a large watershed that cause property damage and other problems normally occur when an extended period of very heavy rains adds too much water for the soils and streams to absorb (Adams & Ringer 1994). Major channel adjustments have resulted from infrequent extreme flood flows. Forest management has had little to do with increasing the size of these events, as will be explained below. In contrast, frequent flows and the bankfull flows are responsible for maintaining channel dimensions and moving most of the

sediment load[2].

Rain on Snow Events: Snow infrequently persists below 1,800 foot elevation and can stay on the ground a week or more above 2,000 feet and occasionally a month or more above 2,500 feet. Map Hyd-1 shows where the areas above 1,800 feet elevation are in the watershed. This transient snow accumulates and melts faster in openings than in forested areas[3]. A synchronous occurrence of high soil water levels or frozen ground, accumulated snow, intense rain, and warm winds causes rapid melting that adds the snow's water equivalent to the storm runoff. While rain on snow events do occur in the Coast Range, they are not common. Most precipitation in the Watershed is in the form of rain associated with warm fronts and much of the Watershed is low elevation, too low and thus too warm for either appreciable snow fall or for long term retention of the snow that does fall. Also the generally low elevation of the Watershed as a whole means a storm event, which is a rain on snow event on the minority of the Watershed that is above 1,800-2,000 feet elevation area, would produce a conventional rain associated runoff on the majority of the land in the Watershed. Three percent of the total Watershed area, equaling 3,338 acres, is above 1,800 elevation. The parts of the watershed experiencing rain directly on the ground produces most of the runoff. That runoff overwhelms the effect of rain on snow on the fraction of the watershed at the higher elevations. Consequently rain on snow events, in this and other low elevation watersheds in the Coast Range, typically result in flows within the range of variability for high flows produced by intense storm events when there is not snow on the ground. North Fork Coquille Watershed, Cherry Creek, Park Creek, Upper Middle Creek, and Alder Creek drainages are the most susceptible to rain on snow events as these drainages extend above 1,800 feet elevation. Most all the BLM managed lands above 1,800 feet elevation in these drainages are in the Late-Successional Reserve and thus not subject to clearcut harvest for the purpose of meeting economic objectives.

Subsurface Flow Interception by Roads: Jones (2000) observed that roads in experimental drainages in the Cascades that intercept subsurface flows could cause a moderate increase in peak flow events with >1-year return periods. However, these changes in peak flow varied with road design, road location on the slope and soil depth. Jones also observed that subsurface flow interception by roads must be large relative to other factors that affect run off such as precipitation event inputs, and soil moisture storage. The greatest amount of subsurface flows intercepted by roads and delivered to channels coincident with peak discharge were contributed by midslope road segments. These are the road segments midway between ridges and major stream channels that run perpendicular to subsurface flow paths whose road cuts intercepted most of the soil profile (Wemple 1998 cited in Jones 2000). Roads affect peak flows by intercepting subsurface flows and converting them to surface flows, which travel orders of magnitudes faster. While some road and ditch segments direct this surface flow away from streams, those segments connected to streams speed delivery of flow to the streams. This has the potential of synchronizing flows and increasing the discharge peak without affecting the stream flow volume (Jones & Grant 1996).

Channel Response to Flow: Most of the stream miles in the North Fork Coquille Watershed are not sensitive to increases in flow. Steep headwater A type channels are static and neither improving nor degrading. Mid-gradient B type channels controlled by rock or large wood structures are stable, even

2 Frequent flows are the high discharges that return several times each winter. Bankfull flows have a return period of 1.5 to 2 years and fill the active channel.

3 Snow intercepted by the forest canopy tends to melt between storms. This results in a smaller net accumulation of snow on the ground under a stand of trees than in openings. The forest canopy also shelters the snow on the forest floor from the wind and rain that contribute to rapid snow melt (Berris & Harr 1987, cited in Adams & Ringer 1994). Cline and others (1977, cited in Adams; Ringer 1994) found aspect affected snow accumulation in both openings and under forest canopies resulting in south slopes producing only 32% of the water yield increase observed on north slopes following clearcutting. The removal of a closed canopy stand from a north slopes, which had intercepted snow, increased in greater snow accumulation. However, the stand on the south aspect have a more open canopy allowing more snow to penetrate the foliage and accumulate on the forest floor. Consequently, clearcutting on the south aspect did not result in as great of a relative increase of snow accumulation on the ground. Also, wind scouring and sublimation due to higher incidence of solar radiation caused loss of snow from the south facing clearcut.

with increases in flow. Down valley reaches or occasional flats include low gradient C type channels. These channels will continue to be stable and neither aggrading nor degrading. The C channels that have downcut and converted to F type channels, mostly along lower mainstem, will continue to be unstable and provide sediment inputs by bank cutting during large storms (Rosgen 1994).

Timing of Flows: Minor increases in the amount of daily flow in the spring and fall may result following harvest activities. This is a result of the younger vegetation transpiring less water and allowing more water to route to the stream channel. This increase is usually considerably less in magnitude than the frequent flows (those flows that occur several times each winter, but are less than the annual high flow) and has little effect on overall flow.

Peak flows during fall and spring periods are likely to be increased following clearcut harvest. This is also primarily due to reductions in transpiration and interception losses resulting in increased soil moisture content. As the rains occur, less precipitation is needed to saturate these soils and the excess water enters the stream system primarily through subsurface flow. This results in a rise in stream levels earlier in the fall and allows peak plows in the spring to be larger than under undisturbed conditions. (Jackson & Van Haveren 1984 cited in Reiter & Beschta 1995, and Harr 1976 cited in Adams & Ring 1994). However, fall and spring peak flows are generally much smaller than the larger peak flows that typically occur during large storms in midwinter.

Jones (2000), in an analysis of hydrologic processes in experimental drainages in the Cascade observed statistically significant increases in peak discharges, attributed to changes in evapotranspiration during the first 8 to 10 years following harvest. The affected flow events were small having <0.22- or 0.28-year return periods and occurred in the fall when the soils were moisture deficient. For a given amount of canopy removed, the initial increases in these small fall events were greater in drier drainages than in the more moist ones.

In the Coast Range, the response time of streams to storms is "flashy" because of limited soil and groundwater storage. It is thought that roads interacting with clearcuts in a watershed act positively in advancing timing for a particular storm (Jones & Grant 1996). High ditch flows during very intense storms have been observed along roads with insufficient numbers of cross drains in the Watershed. Under more normal conditions ditch lines carry little water. Roads and ditch lines may be acting as extensions of the stream network and channel the precipitation directly into the stream system. Midslope roads could be intercepting subsurface flow moving in a downslope direction. These factors result in a quicker rise of the stream flow followed by a quicker drop than may have happened in the past. Compacted surfaces including roads, landings and skid trails may cause long term increased runoff and yield and advance timing when more than 12% of a watershed is occupied by roads or compacted (Harr 1976 cited in Adams & Ring 1994).

Trends and Implications for Meeting ACS Objectives and for Restoration:
The normal regrowth of vegetation on past clearcut units will result in passive restoration of those aspects of the hydrology on BLM lands in this Watershed affected by evapotranspiration.

Currently about 75% of BLM lands in this watershed support stands that have evapotranspiration rates associated with mature stands. The Standards and Guidelines limit the portion of the BLM lands subject to denuding. These limits combined with the regrowth in older plantations will allow the portion of BLM lands in this Watershed that have evapotranspiration rates comparable to mature stands to level off at 88% in about 20 years. Water yield increases are usually only detected when at least 20-30% of the watershed has been harvested (Bosch & Hewlett 1982). When present stand age structures and future regeneration harvests considered, the influence of past and current harvesting on evapotranspiration rates, and by extension on stream flows, will be undetectable in less than 10 years on BLM lands in this watershed.

Trees inside the Riparian Reserve will intercept and transpire water in the soil made available by regeneration harvest on Matrix lands. This will buffer the effect of cutting transpiring vegetation on the hydrology at the small drainage scale.

The literature cited elsewhere in this chapter suggests cutting trees during thinning and density management treatments will have a minor to statistically undetectable effect on stream flows at the drainage scale, and will be statistically undetectable at the watershed scale.

Clearcutting in headwall drainages can increase the size of the fall peak flows produced by those drainages. However, the first fall peak flows are usually small and geomorphically inconsequential in the Coast Range. The very large peak flows, like the one caused by the November 18, 1996 storm, overwhelm the increase in flow due roads or to removal of forest vegetation. Additionally, the extreme peak flows, which modify stream channels and transport most of the sediment, are infrequent and typically occur during midwinter after the soil moisture deficits have been satisfied in both the logged and unlogged watersheds. These extreme peak flows are driven by weather patterns and abetted by geology. Extreme minimum flows are also the result of weather patterns and limited ground water storage capacity.

The road segments that will likely have the greatest impact on stream flows are midslope road segments whose road cuts intercept most of the soil profile, and whose running surface and ditch line flows are delivered to streams. These conditions suggest midslope road segments on the moderate to steep slopes with moderate to shallow depth soils are likely to have a greater potential for converting subsurface flows to surface flow and are therefore the higher priority sites for restoration work than are the midslope road segments on gentle to moderates slopes with deep soil profiles. In the North Fork Coquille Watershed, the combination of moderate to steep slopes with moderate to shallow soils will be most frequently encountered on the Tyee formation. Restoration may include:

- altering the subgrade of midslope roads, which are no longer needed, to improve permeability for subsurface water flow.
- reducing the delivery of water from road surfaces and ditch lines to streams by improving and maintaining cross drainages so that water is redirected away from channels and onto the forest floor. The number and positioning of the cross drains should allow surface water from the road right-of-way to infiltrate into the soil as opposed to cutting new surface channels that could connect with the stream system.

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